

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

INVENTORS' NAMES: Karthik Ramani et al.

ATTORNEY DOCKET NO.: 1165.021US1

CLIENT REFERENCE NO.: P-02132.P1.US

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100

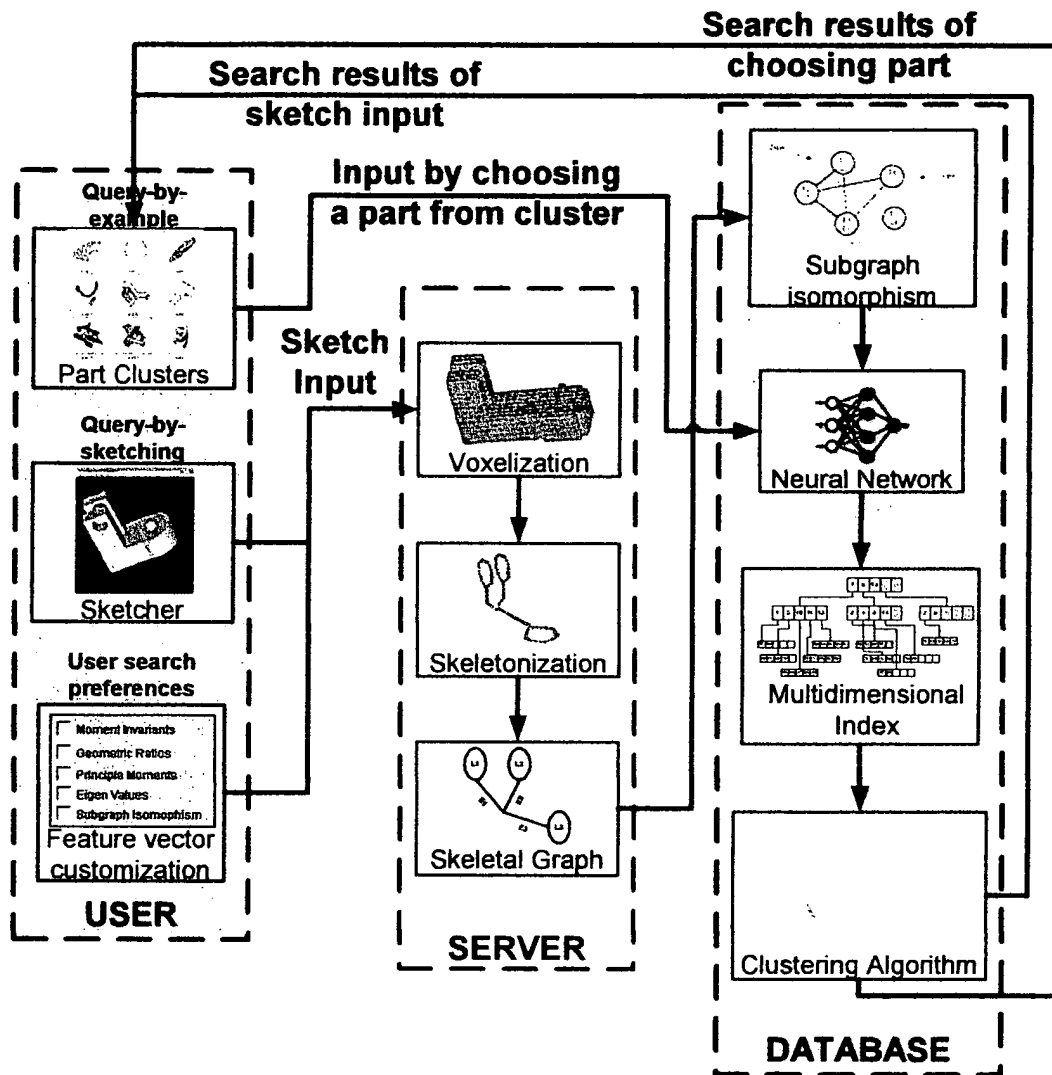


FIG. 1

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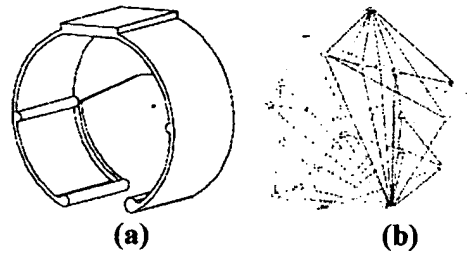


FIG. 2: (a) CAD model (b) B-Rep Graph

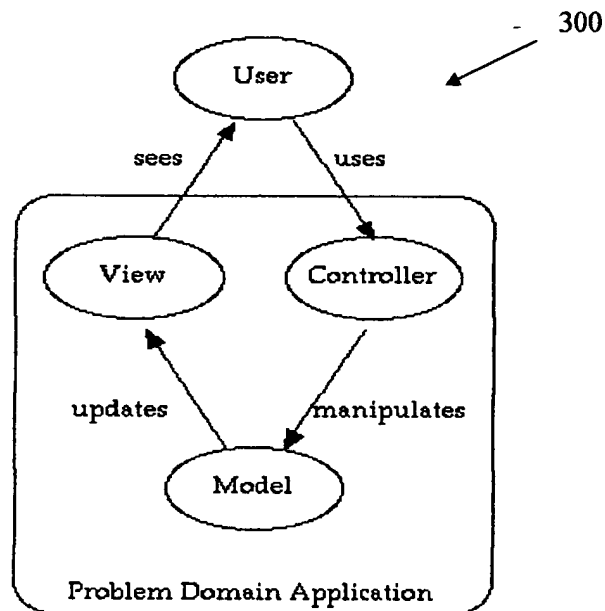


FIG. 3

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400

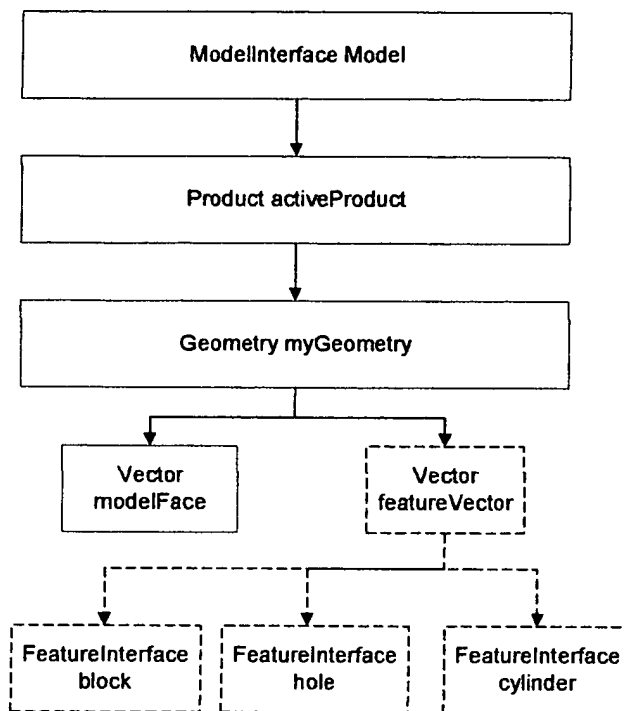


FIG. 4

500

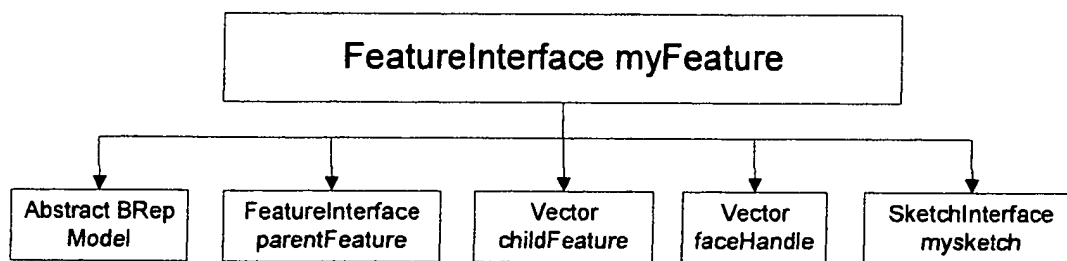


FIG. 5

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600

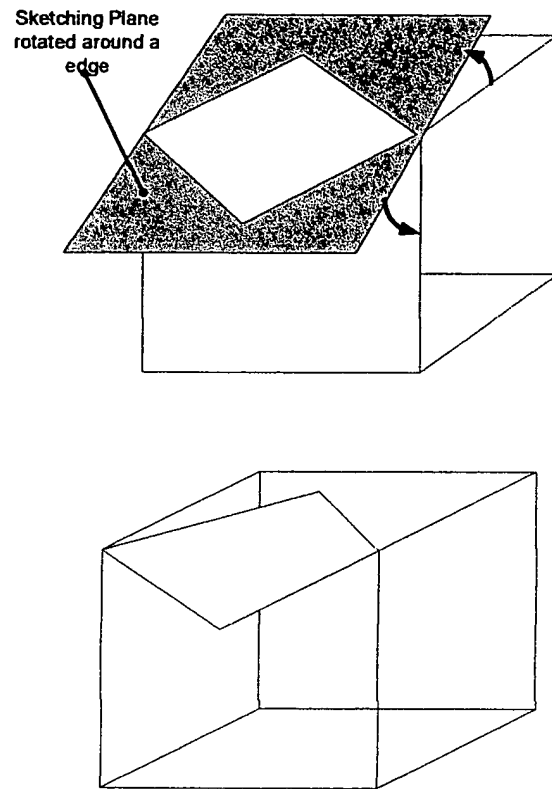


FIG. 6

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700

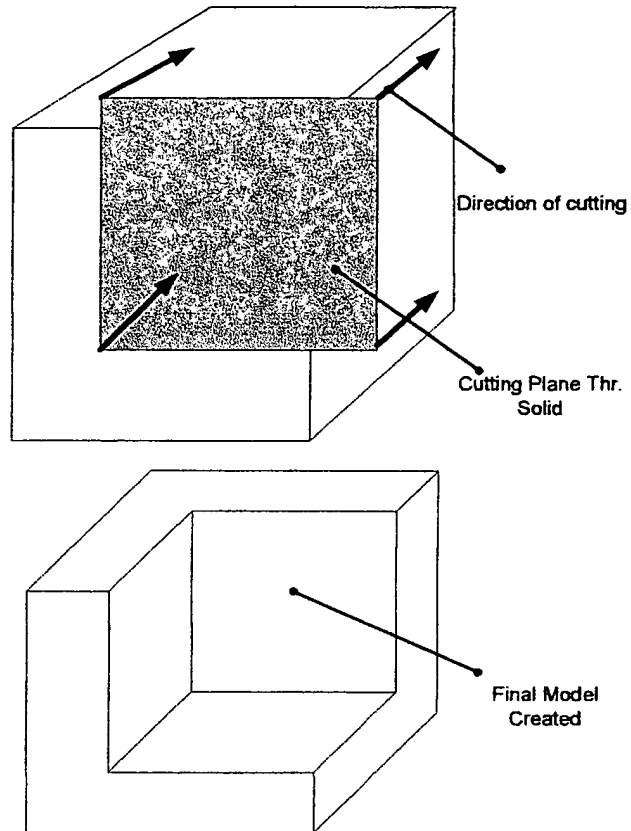


FIG. 7

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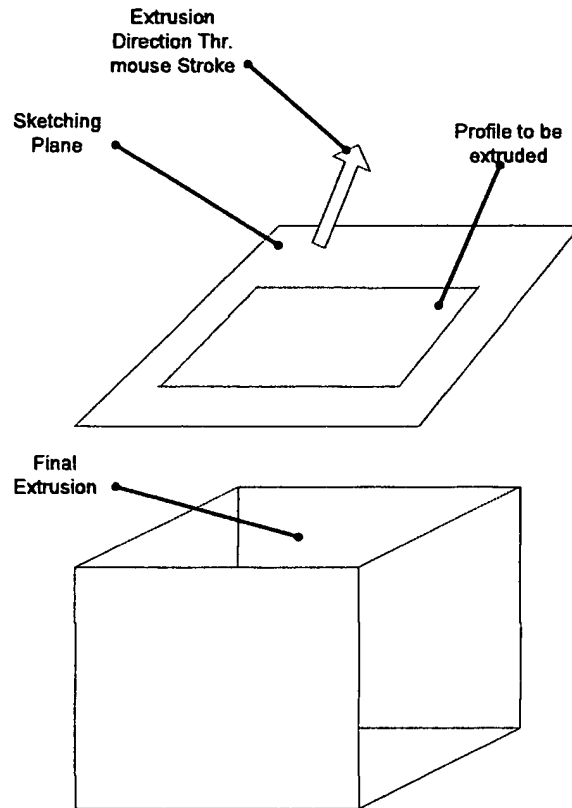


FIG. 8

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900

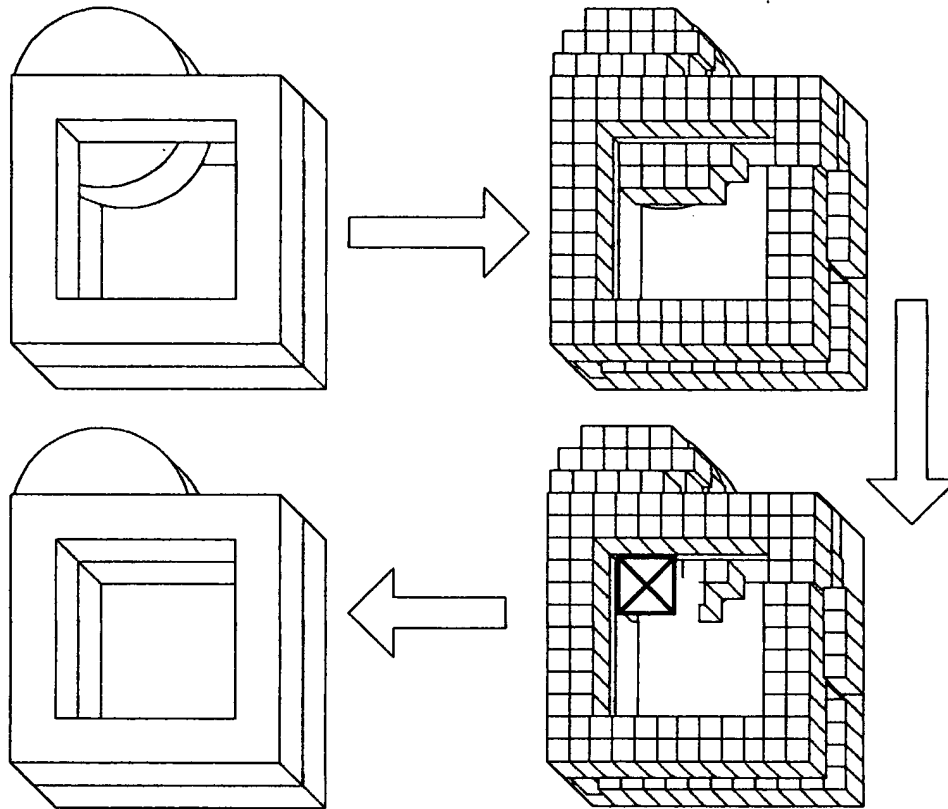


FIG. 9

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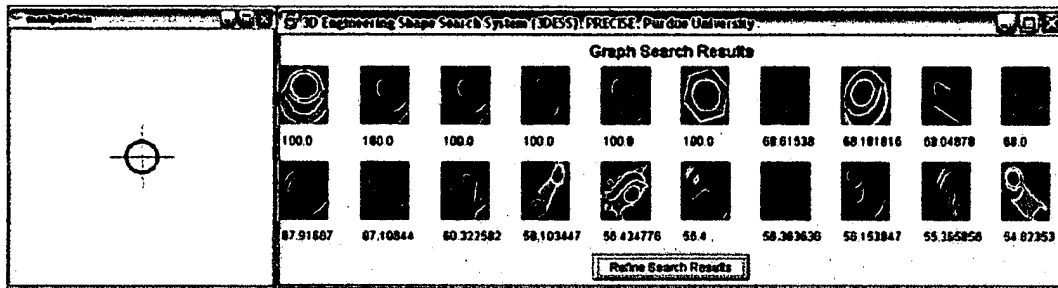
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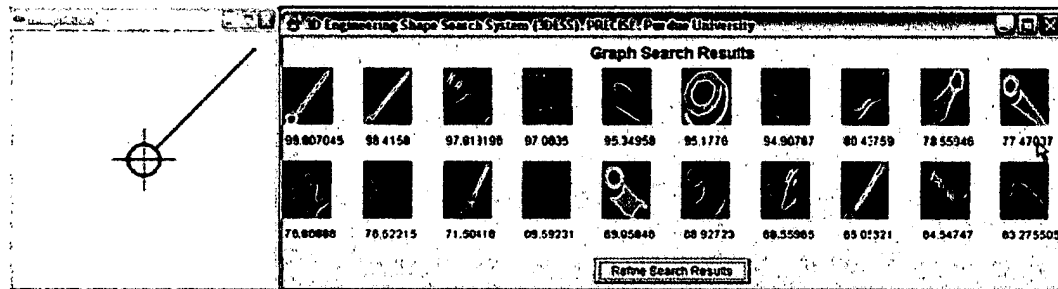
1000



Query

Search Results

(i) Initial Skeleton Query



Query

Search Results

(ii) Modified Skeleton Query

FIG. 10

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1100

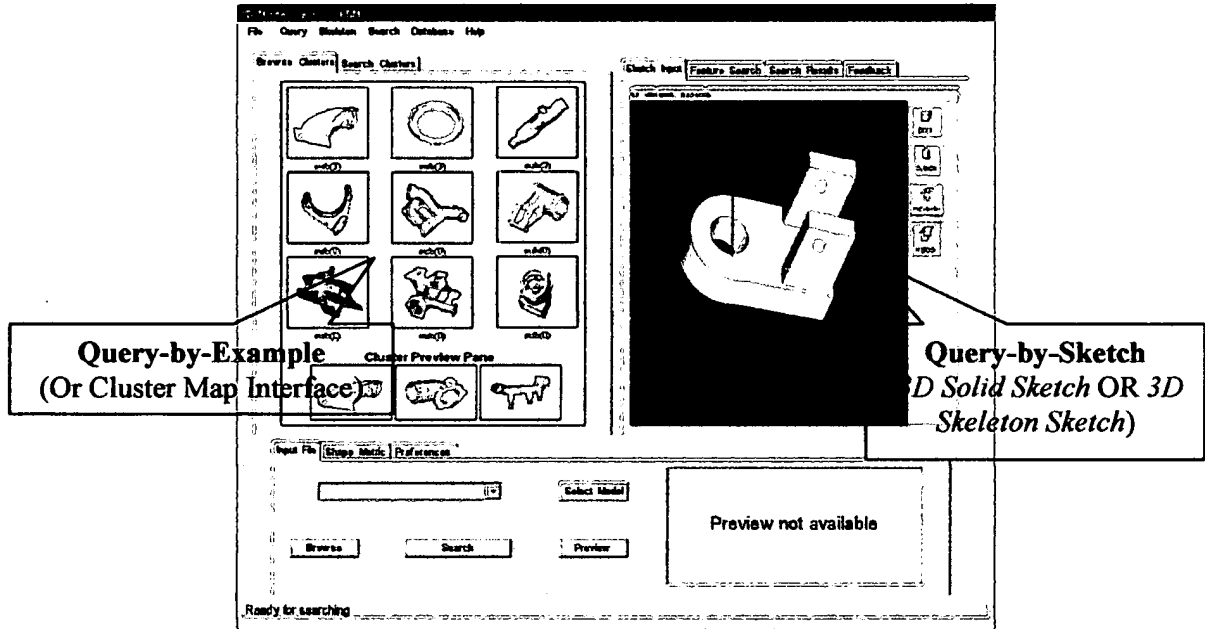


FIG. 11

1200

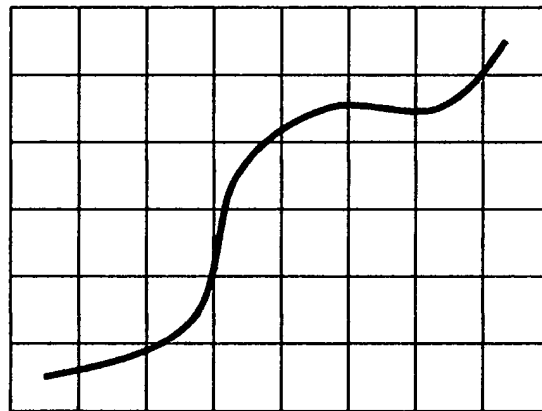


FIG. 12

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

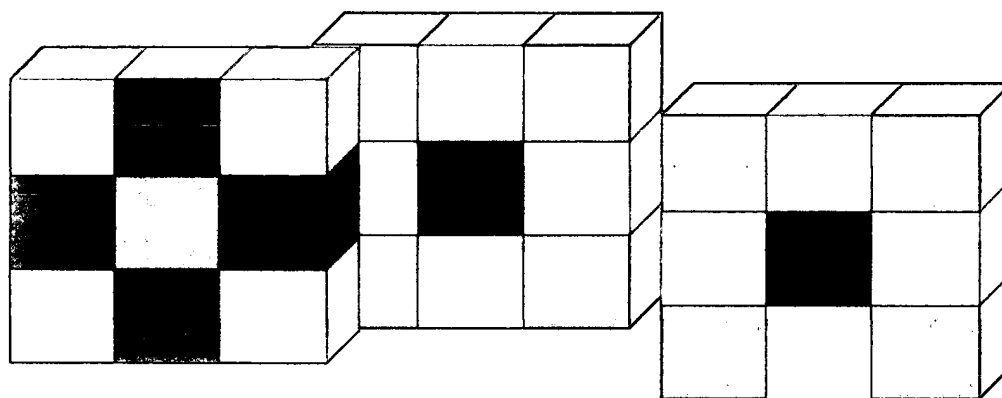
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1300






-  6 neighbors (plane)
-  12 neighbors (edge)
-  18 neighbors (point)

FIG. 13

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1400



```
Read in B-Rep model M
Assign FaceIDs F to all faces in M
Assign EdgeIDs E to all faces in M
Set voxel size S
Find B-Rep model bounding box
Find discrete bounding box coordinates X, Y, Z
Create voxel text file T

for i in X in increment of S:
  for j in Y in increment of S:
    for k in Z in increment of S:
      construct voxel v of size S using ACIS
      test intersection of v with M using ACIS
      if v intersects with M:
        store "1" in T
        find faces intersecting with v using ACIS
        find edges intersecting with v using ACIS
        store F and E for all intersecting faces in v
      else:
        store "0" in T
```

FIG. 14

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1500

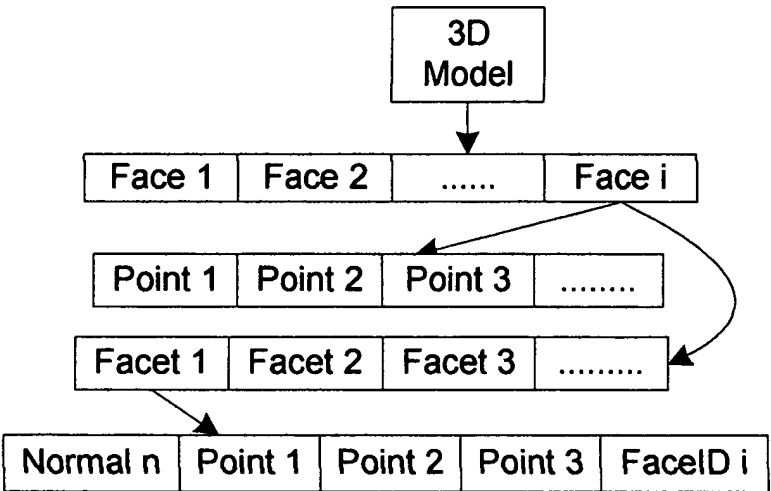


FIG. 15

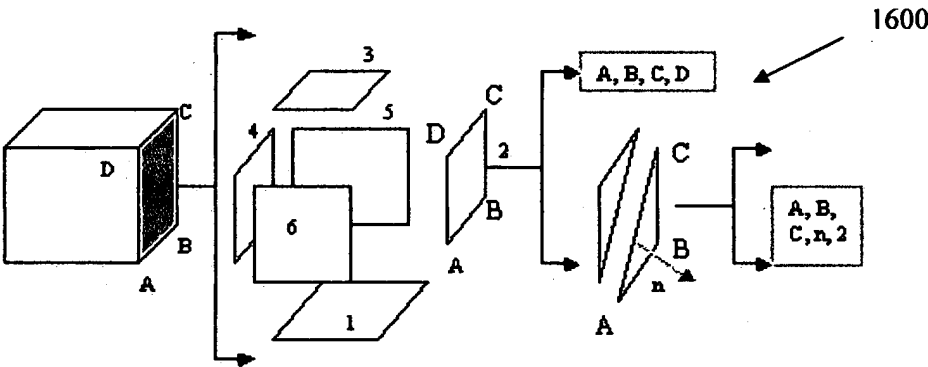


FIG. 16

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
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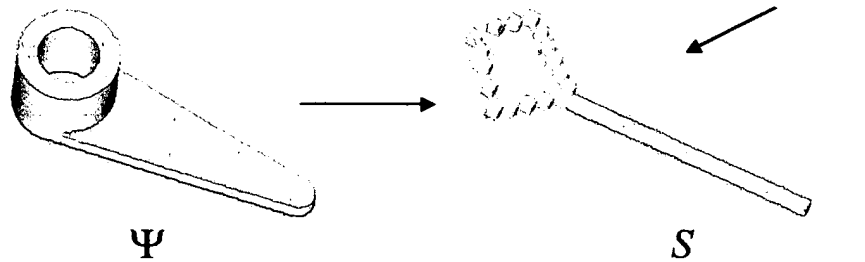
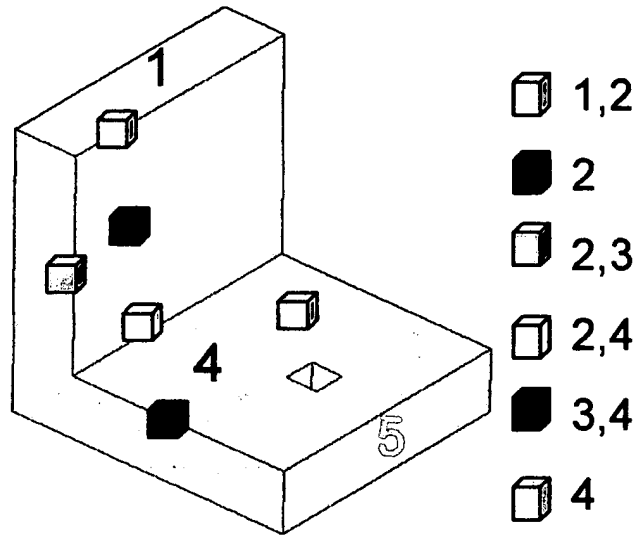
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1700



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1900

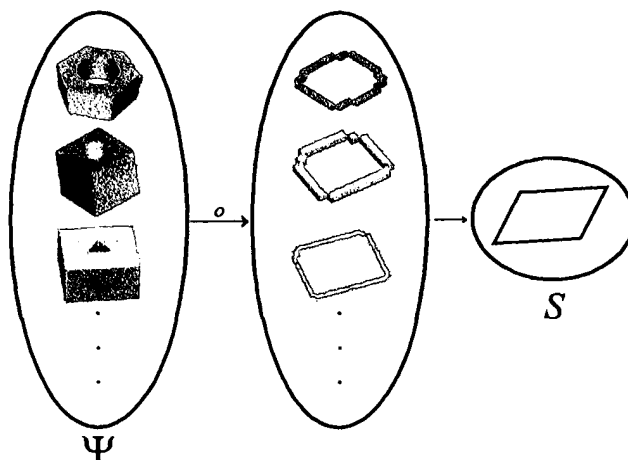


FIG. 19

2000

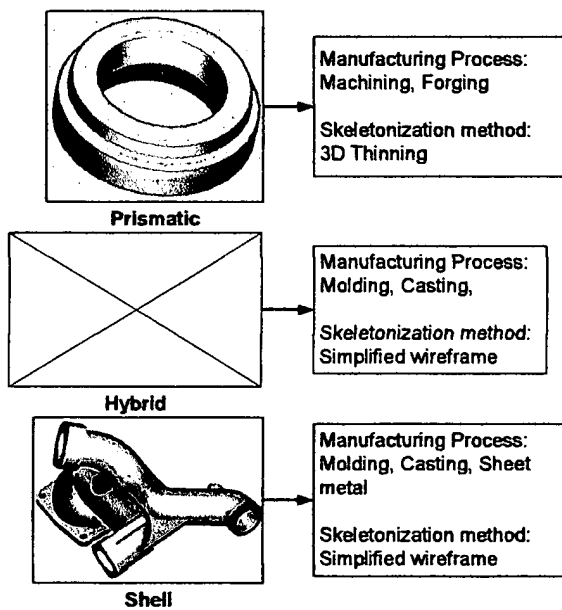


FIG. 20

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2100

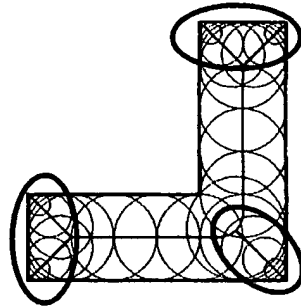


FIG. 21

2200

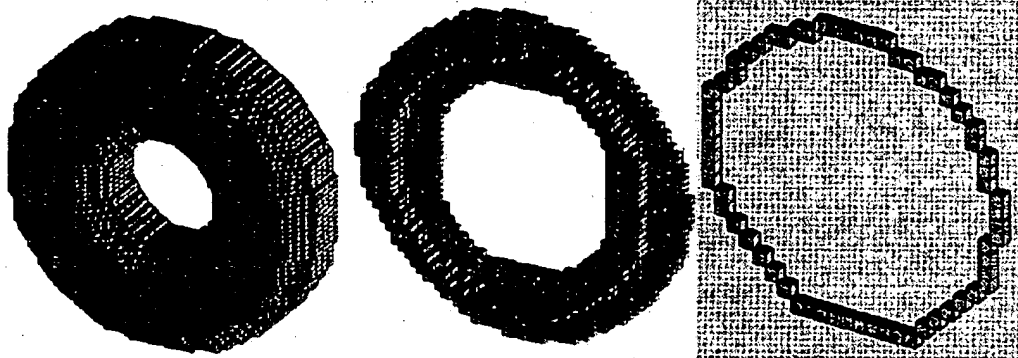


FIG. 22

2300

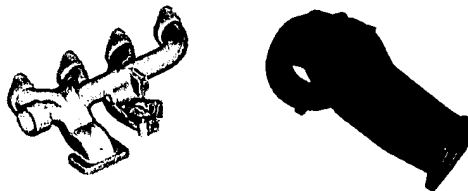


FIG. 23

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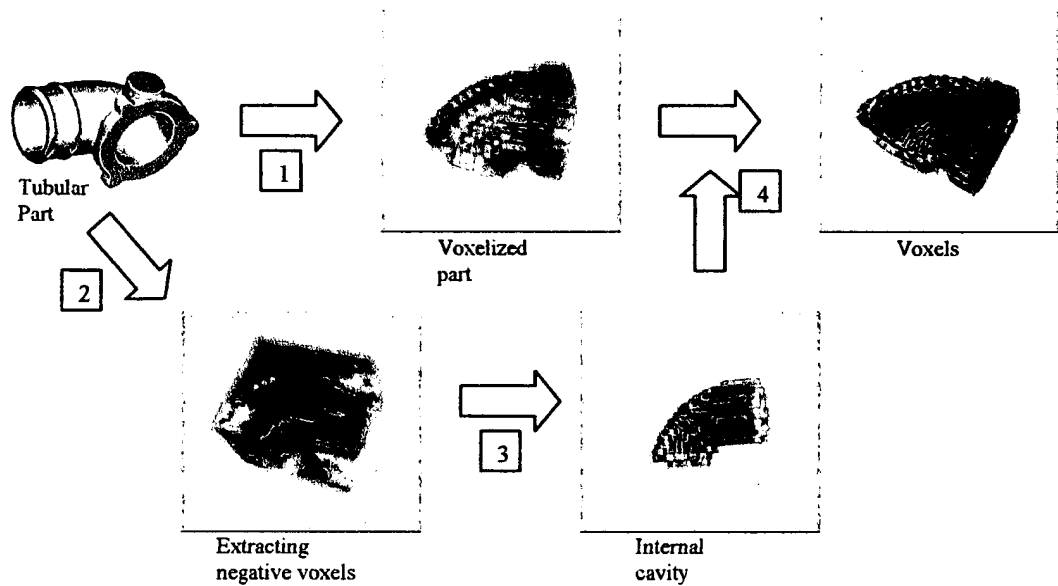
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2400



FIG. 24

2500



A step of converting tubular structure to prismatic structure

1. Voxelize a part volume
2. Voxelize a cavity volume
3. Gain internal cavity voxels using a degree of visibility
4. Merge part voxels and internal cavity voxels

FIG. 25

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SEARCHES ON THREE DIMENSIONAL OBJECTS

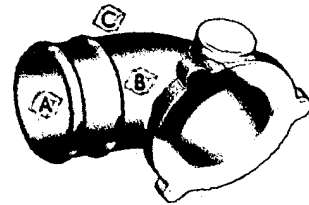
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2600



Center voxel

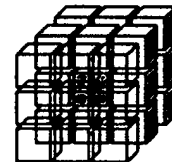


visible direction

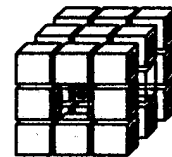


invisible direction

A



B



C

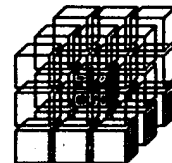


FIG. 26

2700

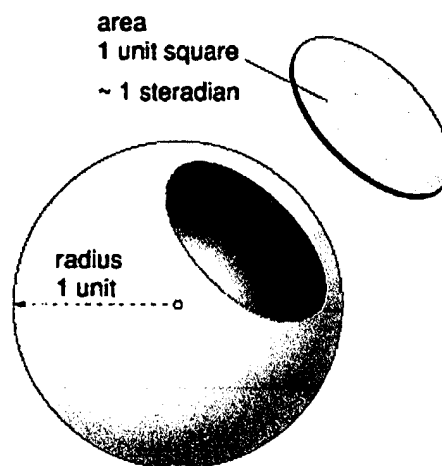


FIG. 27

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2800

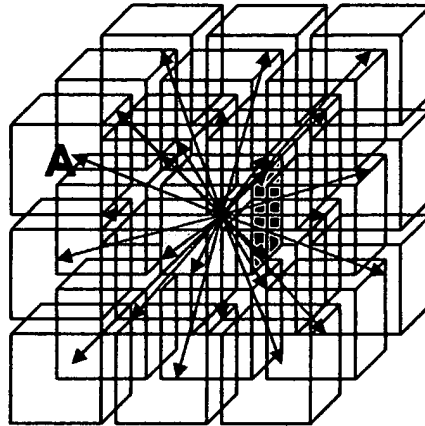


FIG. 28

2900

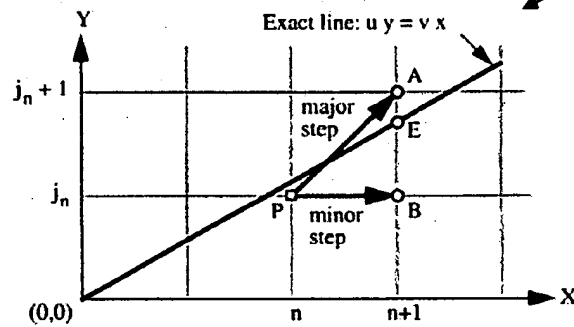


FIG. 29

BEST AVAILABLE COPY

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3000

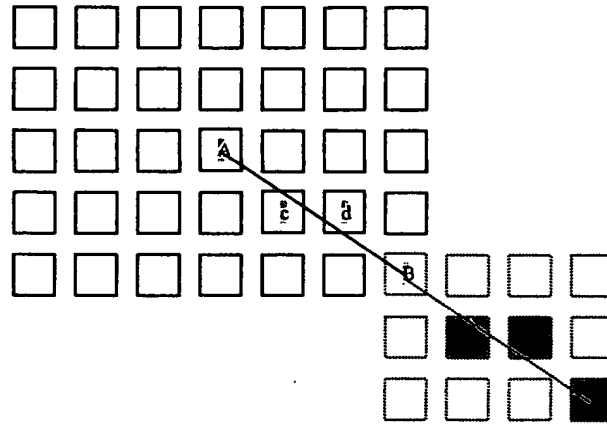
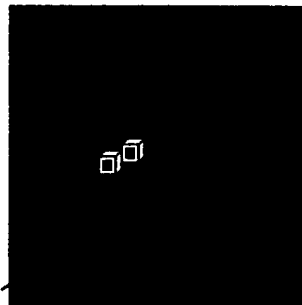
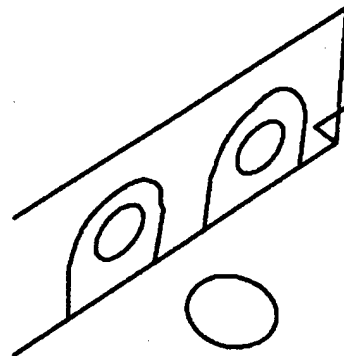


FIG. 30



x - Mark as 'Delete'
d - Diameter of swept cylinder



3100

FIG. 31

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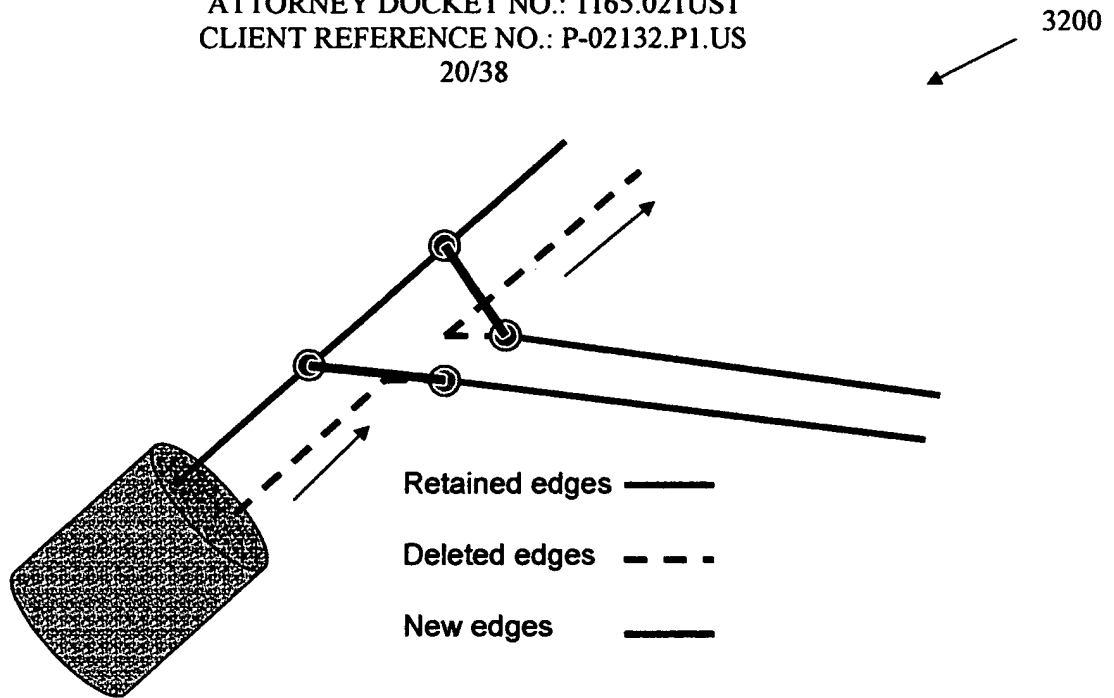


FIG. 32

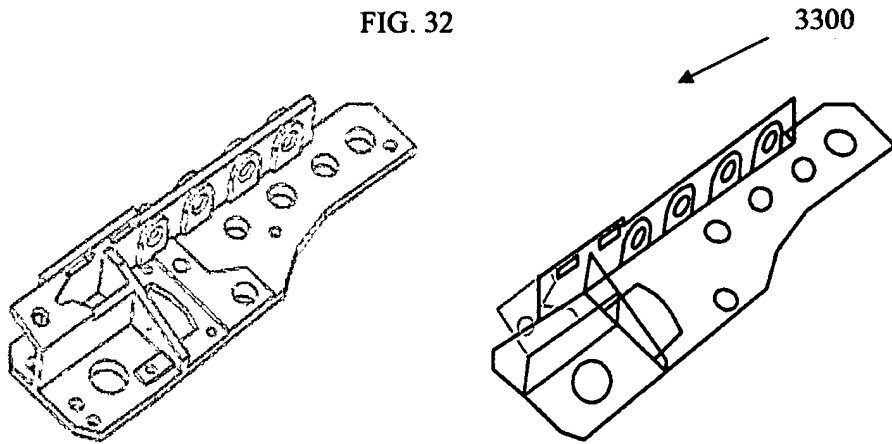


FIG. 33

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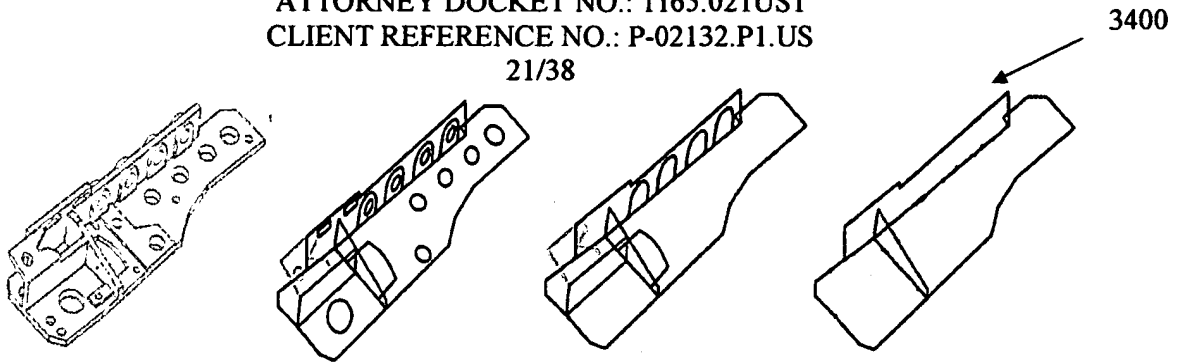


FIG. 34

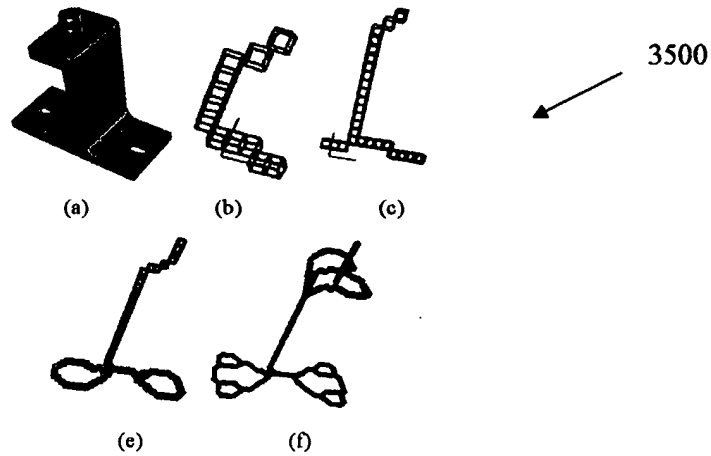


FIG. 35: (a) 3D model, (b) Levels of detail (LOD) for $n = 2$, (c) LOD for $n = 3$, (d) LOD for $n = 4$, (e) LOD for $n = 5$

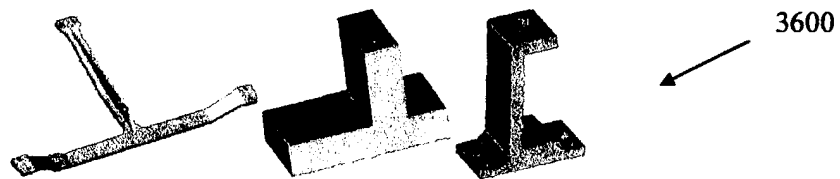


FIG. 36

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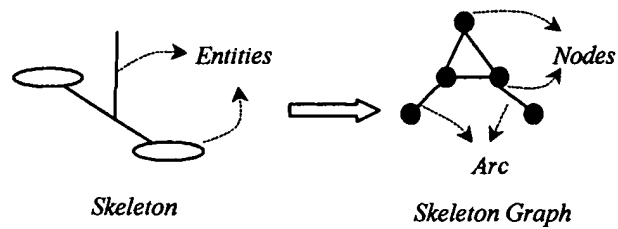


FIG. 37

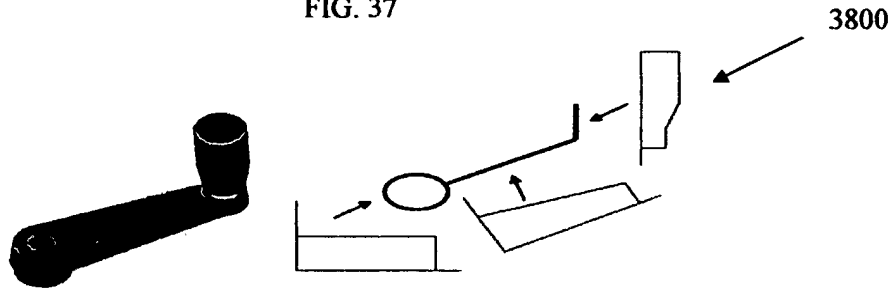


FIG. 38

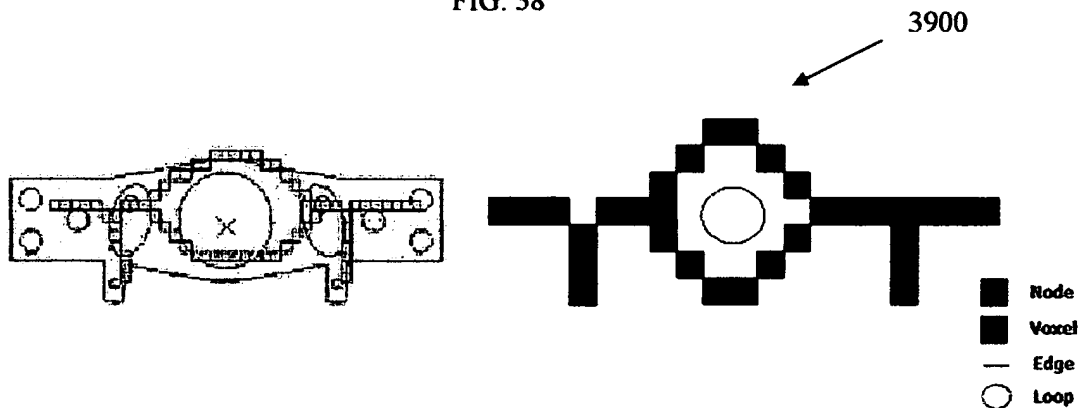


FIG. 39

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

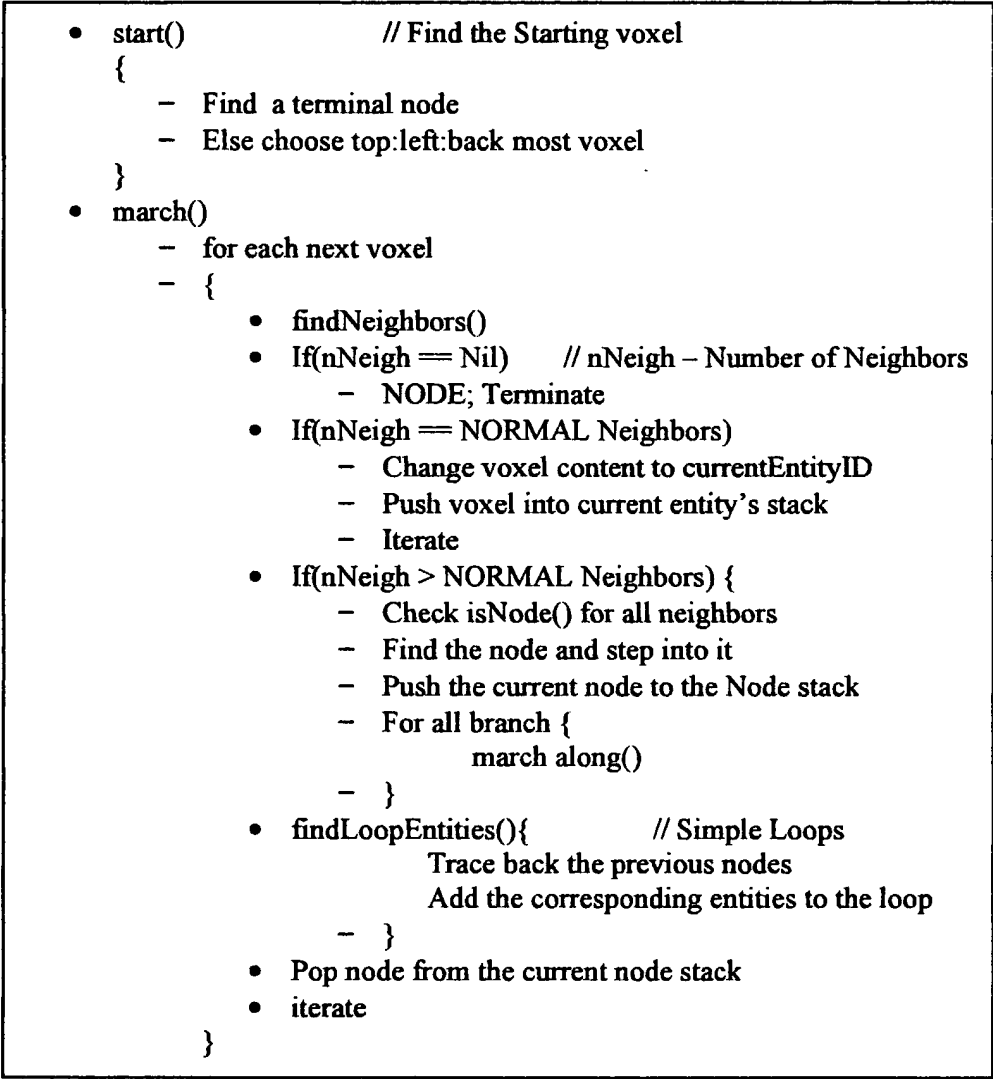
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4000



```
• start()          // Find the Starting voxel
{
  - Find a terminal node
  - Else choose top:left:back most voxel
}
• march()
  - for each next voxel
  - {
    • findNeighbors()
    • If(nNeigh == Nil)    // nNeigh – Number of Neighbors
      - NODE; Terminate
    • If(nNeigh == NORMAL Neighbors)
      - Change voxel content to currentEntityID
      - Push voxel into current entity's stack
      - Iterate
    • If(nNeigh > NORMAL Neighbors) {
      - Check isNode() for all neighbors
      - Find the node and step into it
      - Push the current node to the Node stack
      - For all branch {
        march along()
      }
    }
    • findLoopEntities(){          // Simple Loops
      Trace back the previous nodes
      Add the corresponding entities to the loop
    }
    • Pop node from the current node stack
    • iterate
  }
}
```

FIG. 40

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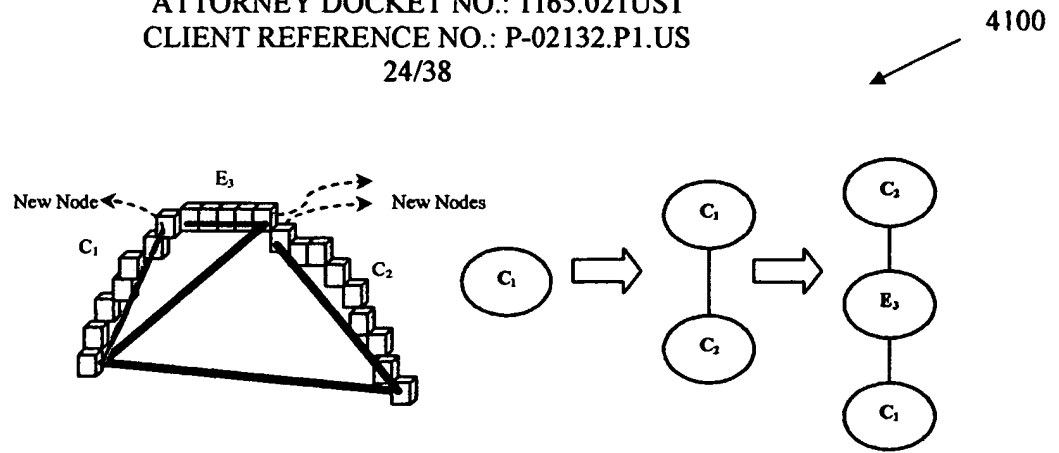


FIG. 41

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4200

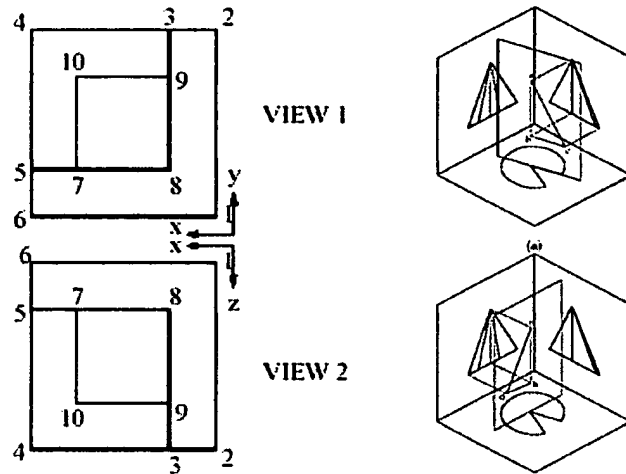


FIG. 42

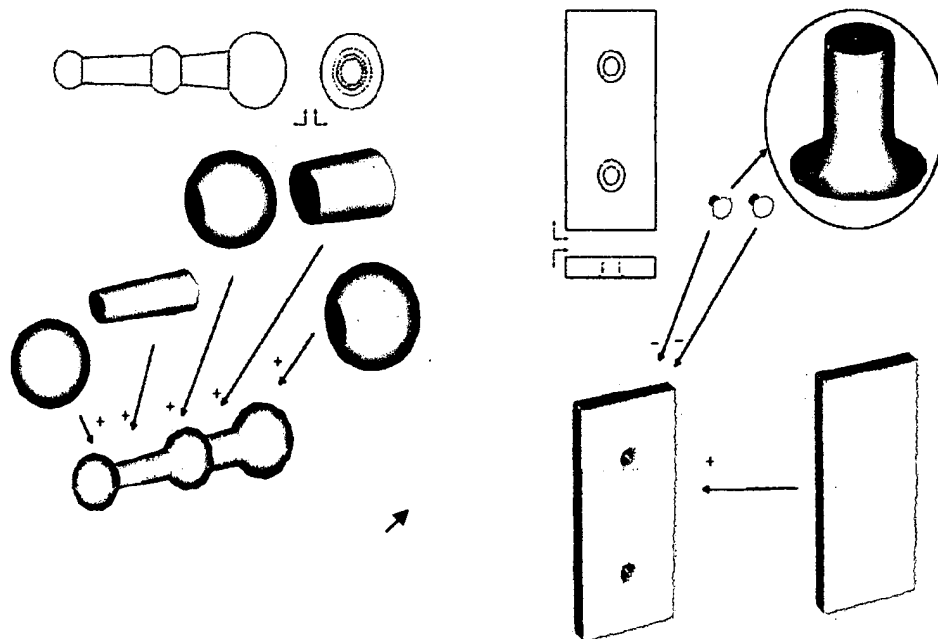


FIG. 43

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

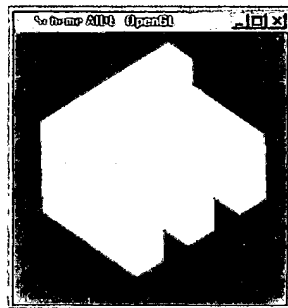
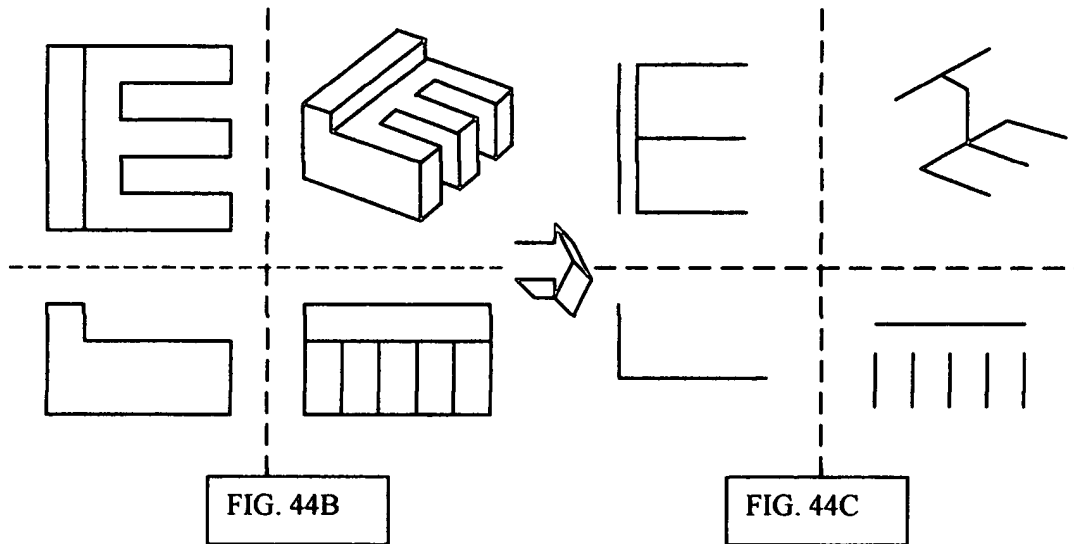
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4400



Actual 3D Model

Fig. 44A

FIG. 44

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4500

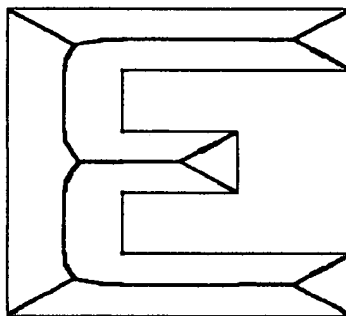


FIG. 45

4600

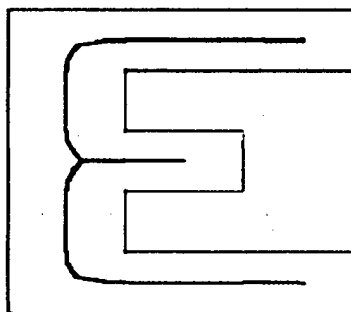


FIG. 46

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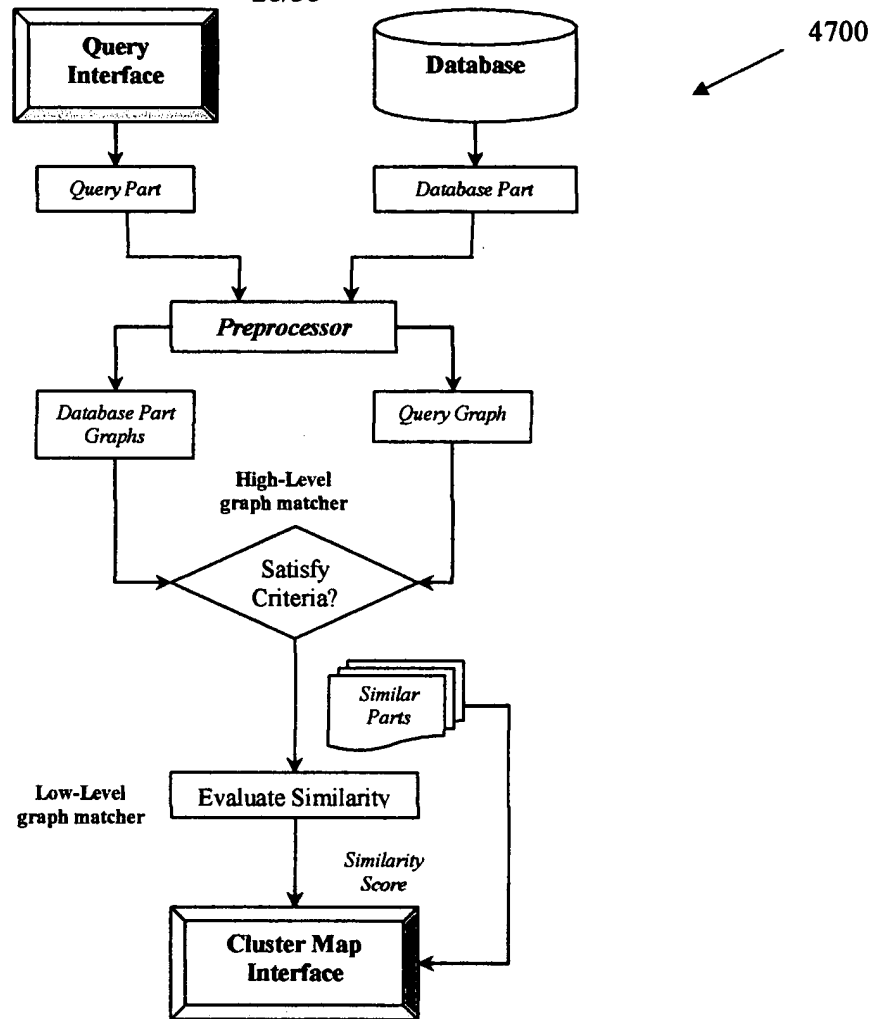


FIG. 47

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

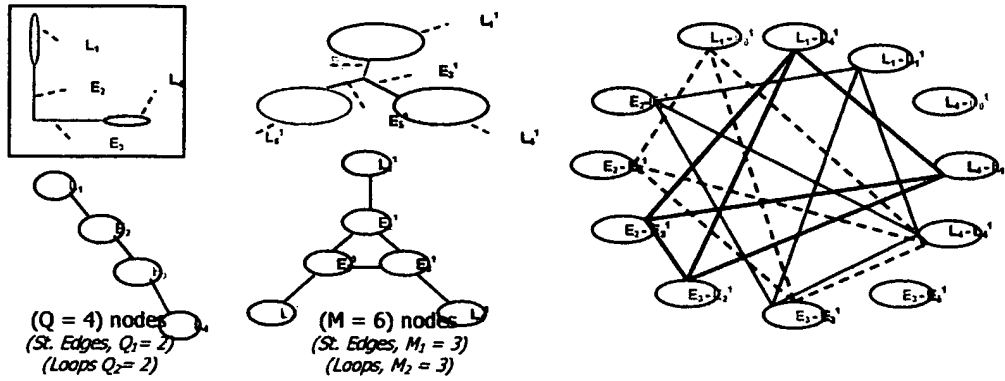
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CLIENT REFERENCE NO.: P-02132.P1.US

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4800



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INVENTORS' NAMES: Karthik Ramani et al.

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5000

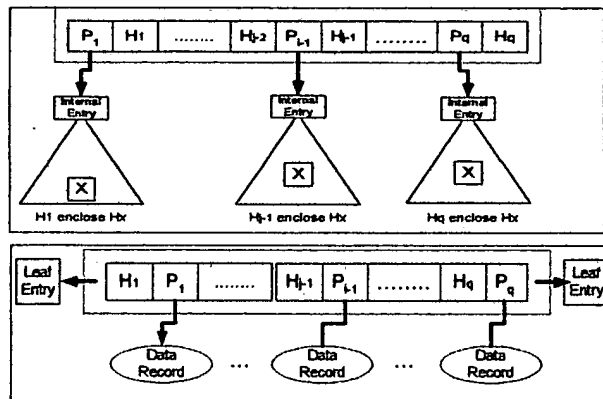


FIG. 50

5100

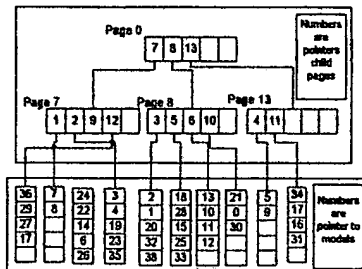


Figure 51A

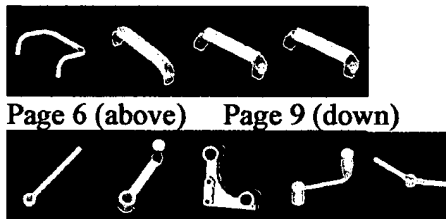


Figure 51B

FIGS. 51A and 51B

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

INVENTORS' NAMES: Karthik Ramani et al.

ATTORNEY DOCKET NO.: 1165.021US1

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5200

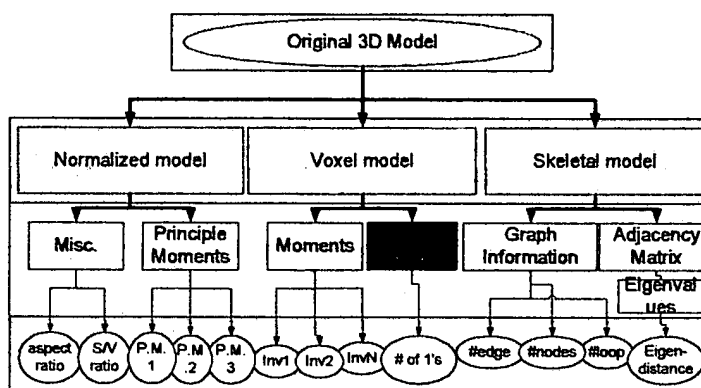


FIG. 52

5300

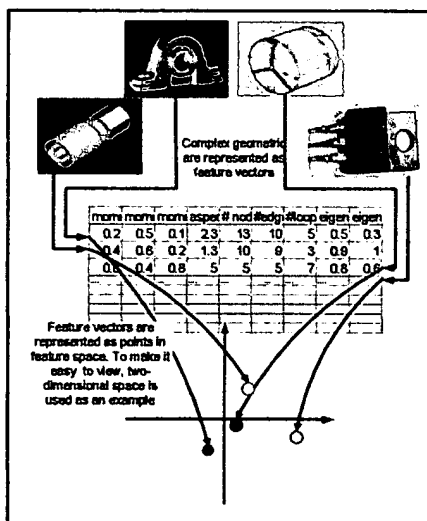


FIG. 53

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

INVENTORS' NAMES: Karthik Ramani et al.

ATTORNEY DOCKET NO.: 1165.021US1

CLIENT REFERENCE NO.: P-02132.P1.US

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5400

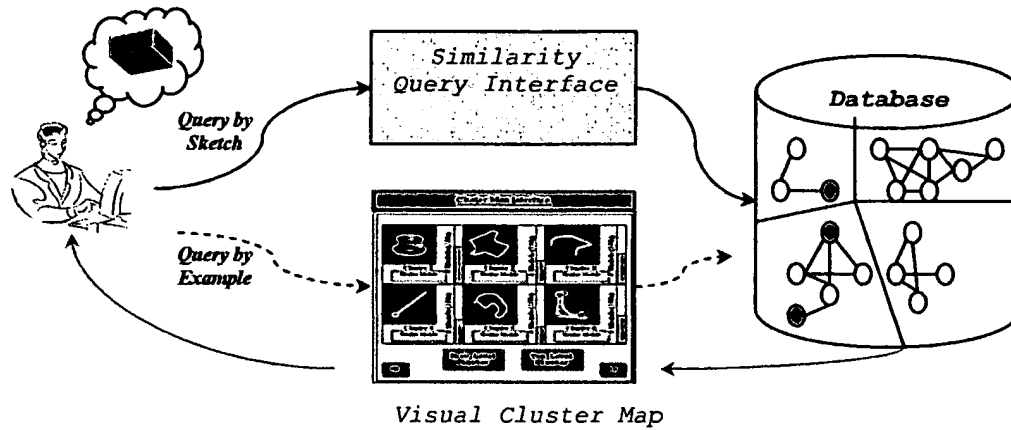


FIG. 54

5500

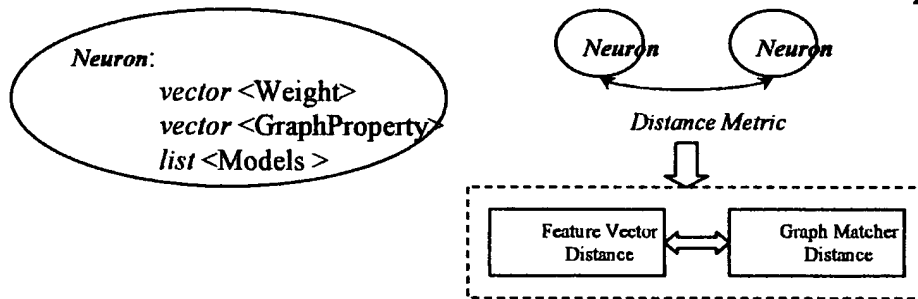


FIG. 55

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

INVENTORS' NAMES: Karthik Ramani et al.

ATTORNEY DOCKET NO.: 1165.021US1

CLIENT REFERENCE NO.: P-02132.P1.US

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5600

Automatic Mode



Automatic
clustering

Interactive Mode



Reconfigure Similarity /
Browse / Pan / Zoom /
Rotate

Updated Part
Cluster Map

FIG. 56

5700

Cluster
Browser

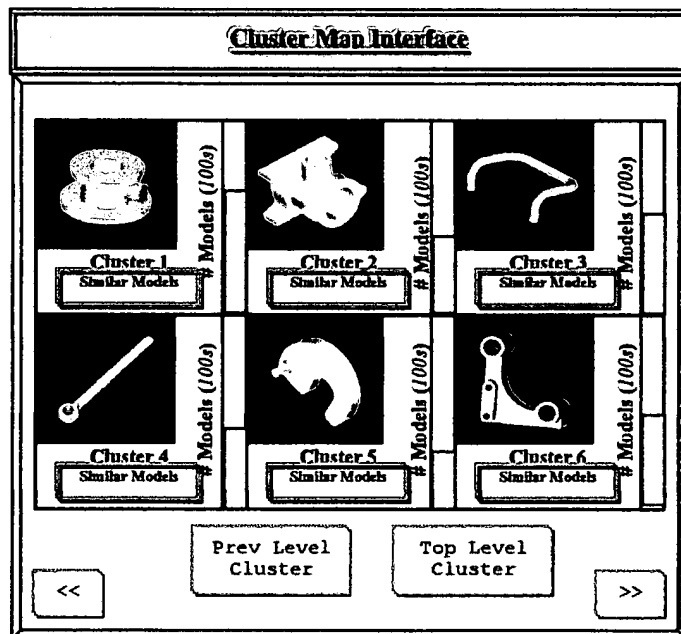


FIG. 57

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

INVENTORS' NAMES: Karthik Ramani et al.

ATTORNEY DOCKET NO.: 1165.021US1

CLIENT REFERENCE NO.: P-02132.P1.US

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5800

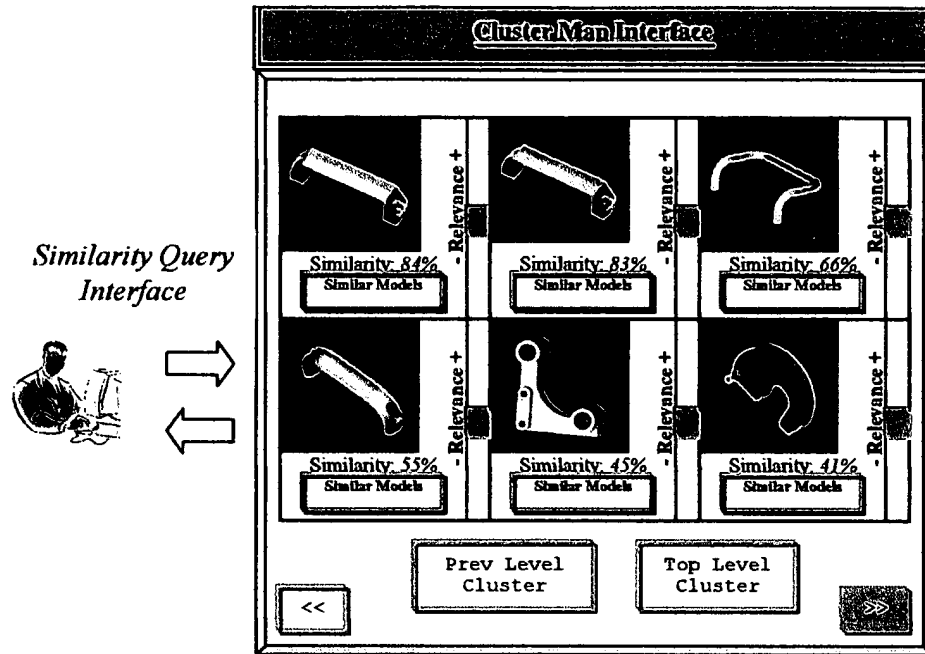


FIG. 58

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

INVENTORS' NAMES: Karthik Ramani et al.

ATTORNEY DOCKET NO.: 1165.021US1

CLIENT REFERENCE NO.: P-02132.P1.US

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5900

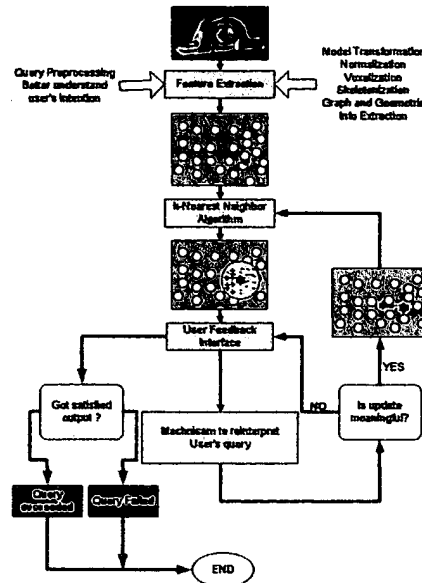


FIG. 59

6000

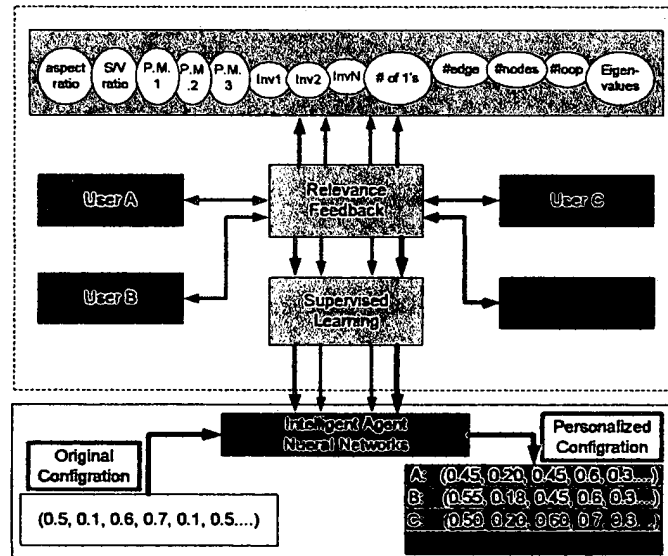


FIG. 60

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

INVENTORS' NAMES: Karthik Ramani et al.

ATTORNEY DOCKET NO.: 1165.021US1

CLIENT REFERENCE NO.: P-02132.P1.US

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6100

Database feature vector			Relevance Feedback	Query Vector		Reconfiguration
No.	F1	F2		F1	F2	
1	0.1	0.2		0.1	0.06	$W_1^{(1)} = W_1^{(0)}$
2	0.2	0.6		0.2	0.2	$W_2^{(1)} = 3 \times W_2^{(0)}$
3	0.3	0.4		0.3	0.13	
4	0.5	0.6		0.5	0.06	$W_1^{(1)} = W_1^{(0)}$
5	0.6	0.9		0.6	0.09	$W_2^{(1)} = 10 \times W_2^{(0)}$
6	0.7	1.0		0.7	0.10	
7	0.8	0.8				???
8	0.65	0.55				???

FIG. 61

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING SEARCHES ON
THREE DIMENSIONAL OBJECTS

INVENTORS' NAMES: Karthik Ramani et al.

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CLIENT REFERENCE NO.: P-02132.P1.US

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6200

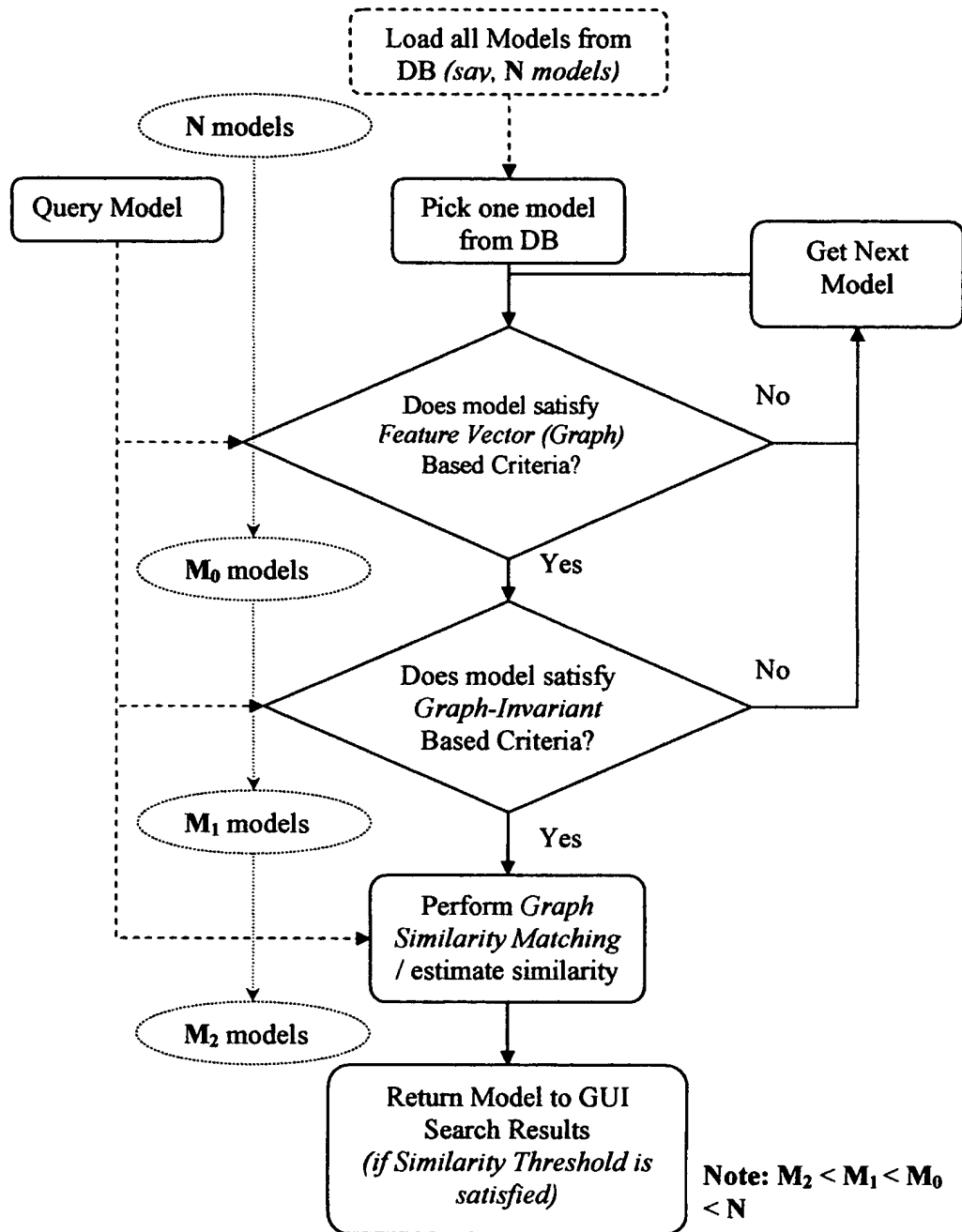


FIG. 62

TITLE: METHODS, SYSTEMS, AND DATA STRUCTURES FOR PERFORMING
SEARCHES ON THREE DIMENSIONAL OBJECTS

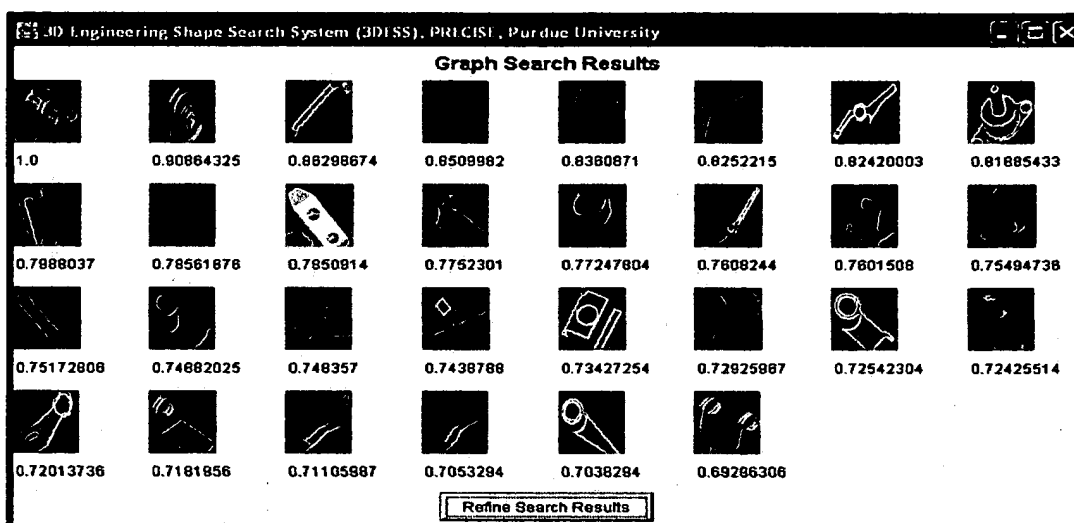
INVENTORS' NAMES: Karthik Ramani et al.

ATTORNEY DOCKET NO.: 1165.021US1

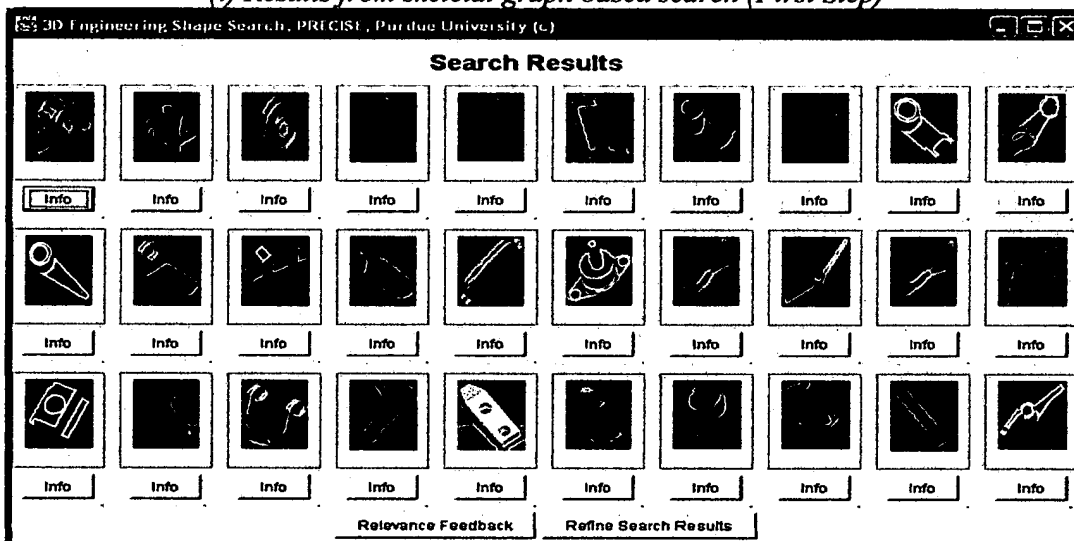
CLIENT REFERENCE NO.: P-02132.P1.US

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6300



(i) Results from skeletal graph based search (First Step)



(ii) Results after refining the query in (i) using moment invariants (Second Step)

FIG. 63